TWO-WAY RADIO COMMUNICATION AT SANTA RITA OPEN PIT, KENNECOTT COPPER CORP., SANTA RITA, N. MEX.

By Allen D. Look and L. A. Van Fleet

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SUMMARY

Use of two-way radio communication at the Santa Rita open pit of the Kennecott Copper Corp. has furnished a satisfactory answer to the problem of communications for an operation covering an extended area. Coordination of operations has resulted, with little loss of time in making changes during the shift. Repairs are facilitated, and safety of operations is increased through better control of blasting and hazardous conditions.

INTRODUCTION

Expansion of mining operations brings increasing needs of improved communications to coordinate the mechanized operations that contribute to the efficiency of present-day open-pit methods. Equipment found satisfactory when first installed becomes inadequate as distances and demands increase. It is the purpose of this paper to record the progress being made by one mine in meeting this problem.

ACKNOWLEDGMENTS

Acknowledgment is made to the Kennecott Copper Corp. for its cooperation in making available data contained in this paper and to the staff of the Chino Mines Division for the helpful suggestions and information furnished.

GENERAL INFORMATION

The Santa Rita open pit of Chino Mines Division, Kennecott Copper Corp., is situated at Santa Rita, N. Mex. Operations consist of the open-pit mine, including a large dump area; an underground mine; a precipitating plant; and necessary shops and administrative units. These operations cover an area about 3 miles in diameter (figs. 1 and 2). Over 1,000 men are employed, and about 50,000 tons of material (ore and waste) is mined daily.

PREVIOUS COMMUNICATIONS SYSTEMS

Whistles - Telephone

When the pit was started, a communication system of whistles and telephones was inaugurated. Train whistles, shovel whistles, and a loud air-blast whistle at the "look-out" or control tower, on the north rim of the pit near the main office buildings, were combined with telephones to form an intricate system of communication among the various operations. The telephones were located at the five switch points along the haulageway and answered by the switch tenders.

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To implement the delivery of whistle-telephone messages a series of roads was built throughout the pit in order that supervisors and foremen could drive their work trucks from level to level to carry instructions, repair parts, and personnel.

As the pit was deepened and surface operations were expanded, problems of communication developed. The whistles had limited range and, with other distracting sounds, often were inaudible to persons on the surface dumps. Whistles can only convey a signal; hence much time was lost and inconvenience experienced by those concerned in translating whistle signals into an intelligible message. Telephones installed at the control tower and at the switch points were restricted to use by those in the immediate vicinity. Electrical and wind storms often damaged telephone lines, even disrupting service for long periods. The progress of the benches in the pit necessitated frequent moving of the telephone wires and poles. After a telephone message was received, much time was lost in contacting the person or persons concerned. Blasting sometimes damaged the telephone wires and poles. The construction and maintenance of roads to all working places in the pit as well as on the surface to insure prompt delivery of whistle-telephone messages proved time-consuming and costly. Although roads in and out of the pit are always necessary to the flow of men and materials, the need for some of the roads would have been eliminated or greatly reduced had a better means of communication been available. Whistle signals also were a one-way situation. Persons for whom the signals were intended had no way of replying until telephone communication could be established or personal contact made.

Trolley Telephones

In an effort to overcome some of the disadvantages of conventional telephone communication, a trolley telephone system was tested in July 1948. One instrument was placed in the control tower and another in the cab of an electric locomotive. Considerable time and expense were involved in installing and testing the trolley telephone, and a number of defects were noted. With 40 miles of track in and out of the pit, numerous blind spots developed along the haulageway. Power was cut off and the locomotive telephone service interrupted when the pantograph lost contact with the overhead trolley wire. In places where the rails were not bonded on the bench tracks, contact with the control-tower telephone was broken. There was a great deal of interference from other locomotives and electrical equipment. Contact with the control tower could not be maintained when the locomotive was on the waste dump.

RADIO COMMUNICATION SYSTEM

With the development of short-wave radio transmission and its adaptability to industrial uses, the management of Kennecott decided to experiment with this new method of communication. It had long been evident that, owing to expanded operations and the need for all possible speed in economical mining of low-grade ore, the communication system already in use was proving inadequate and costly.

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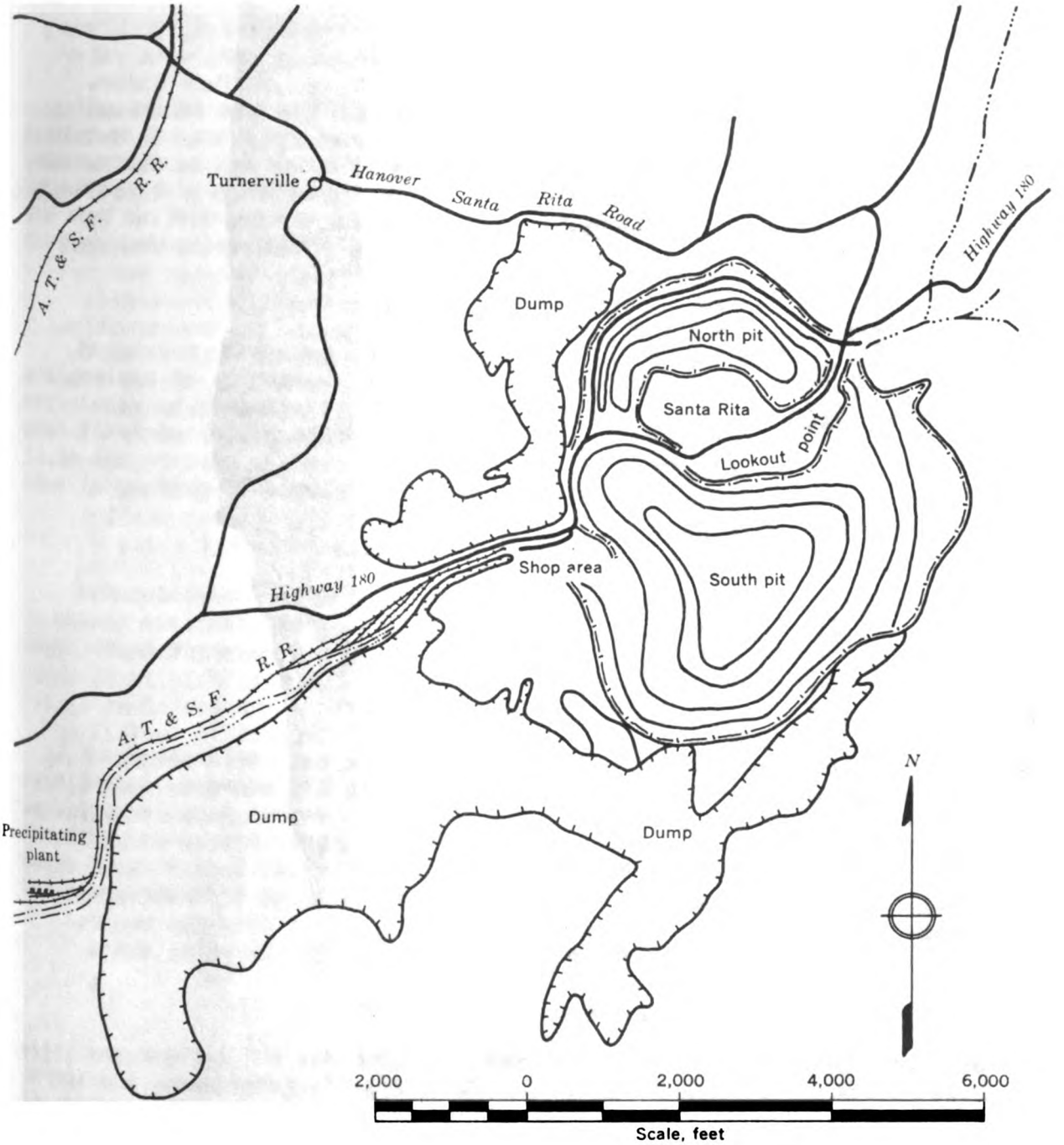

Figure 1. - Map of general area of operations.

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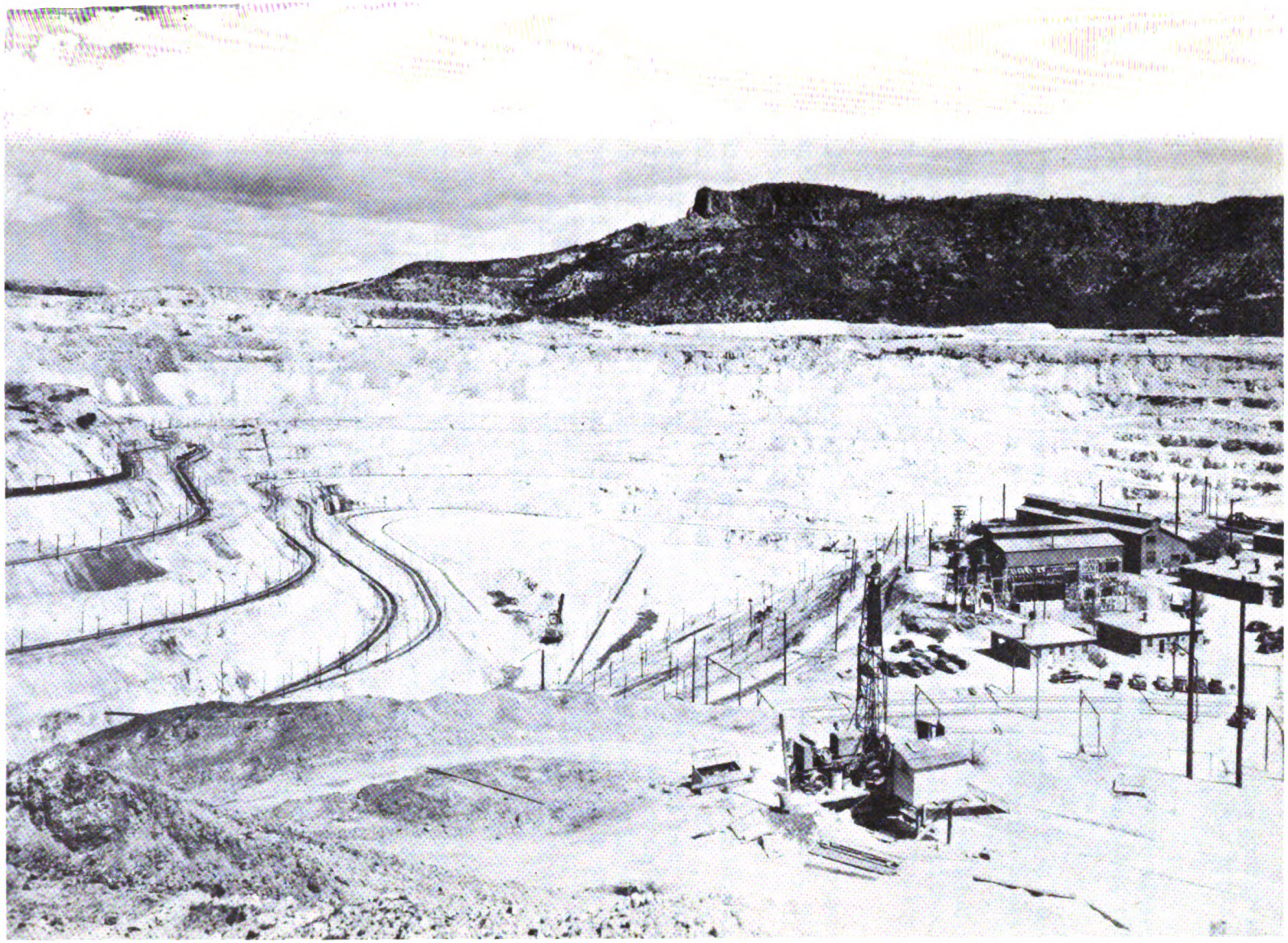

Figure 2. - General view of Santa Rita open pit.

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Preliminary Tests

In late July 1948 two-way radio equipment operating in a frequency range of 152 to 162 megacycles was installed for test purposes. Several types of sets were ultimately tried and given preliminary tests.

A stationary set (transmitter-receiver) operating and 110-volt alternating current was placed in the control tower. A similar set, operating off a storage battery, was placed in the cab of an electric locomotive.

On this comparatively low frequency (152 to 162 mc.), some blind spots developed when the locomotive was in the pit and when it was on the waste dump.

A lower-frequency "FM" set, operating on a 30 to 40 megacycles band, was next installed and given a 24-hour test. Reception was excellent, although there was some interference at this low frequency, especially from police transmitters and other low-frequency sets in the area.

The mobile set originally installed in the locomotive was next transferred to a work truck for road tests. Again reception was excellent, with some occasional interference. The range was up to 5 miles.

To increase the range with a view to establishing radio communication between the mine and the company mill and smelter at Hurley, N. Mex., 10 miles distant, the control-tower apparatus was moved to a higher point near the pit and operated from the control tower by remote control. A 20-foot antenna was also installed for additional height. This relocation of the stationary apparatus increased the range to 10 miles and provided contact with the Hurley plant. Thus it was found that, by using a lower-frequency set and by placing the instrument (transmitter-receiver) at a higher point with a 20-foot antenna, the coverage of the sets could be doubled in radius.

As radio contact with the Hurley mill and smelter was not needed at present, permanent installations necessary to effect and continue such contact were not deemed advisable and the project was abandoned. The equipment was subsequently returned to the control tower for continued testing to meet local needs. To avoid possible interference on the 30- to 40-mc.-frequency sets and because this interference might prove more annoying than the blind spots experienced on the higher-frequency sets, the lower-frequency sets were finally replaced by the original sets tested on the 152- to 162-mc. band.

By late August 1948, or approximately 1 month after the test sets were first installed, the new method of two-way radio communication proved itself to the extent that plans were formulated to adopt and install the new system. Consequently, application was made to the Federal Communications Commission to construct and operate a base station and 30 mobile units at Santa Rita. In the new set-up, the whistles and telephones were not to be completely abandoned but would be used for supplemental purposes.

Although only two sets were used, the stationary and the mobile, in making the preliminary tests for radio communication these tests seemed sufficient to establish several conclusions. Intercommunication could be made possible at

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all times without interference or static at any point in the operational area. The mobility of the sets would eliminate much delay in transmitting work orders, making repairs, and the movement of personnel. Maintenance costs probably could be kept at a minimum. Disruption of service by causes set forth in the discussion of previous systems would be largely eliminated. More communication points could be established simply by installing additional sets as the need arose and regulations permitted.

Permanent Installation

During the few weeks the application for license to construct and operate the station was being processed, additional plans were made to inaugurate the system as soon as official approval was received.

Under the Federal license the stationary transmitter-receiver was installed in the control tower on February 24, 1949. One set was installed each day after that date in several mobile units.

Although the mobile set for test purposes in the electric locomotive was operated off a storage battery placed temporarily in the cab, no suitable device for keeping the battery charged for continuous operation was available at that time. Hence the mobile sets first installed under the license were placed only in the automotive trucks where a generator or battery charger was already in use for charging the truck battery. Meanwhile, investigation was made as to the possibility of securing a battery charger that could be installed in the locomotive cab in a practicable and economic manner. Before the year was over a heavy-duty, slow-speed generator developing 80 amperes current, which could be operated off the motor of the air compressor in the forward section of the locomotive cab (fig. 3), was purchased and proved satisfactory. The installation of radio sets in all the pit locomotives proceeded accordingly.

The efficiency of the generator used for charging the storage battery in the locomotives resulted in replacement of the conventional truck generators with the same type heavy-duty generators for a number of the work trucks. However, a 45-ampere generator was found sufficient to keep the truck batteries charged for continuous 24-hour daily operation. Installation of the generators in the trucks (fig. 4) was made comparatively easy by the use of adaptable mountings purchased with the generators.

Units in Operation

When this circular was written 21 sets had been installed, as follows:

1	control tower (stationary)
10	trucks (mobile)
8	electric locomotives (mobile)
1	Diesel locomotive (mobile)
1	crane (mobile)

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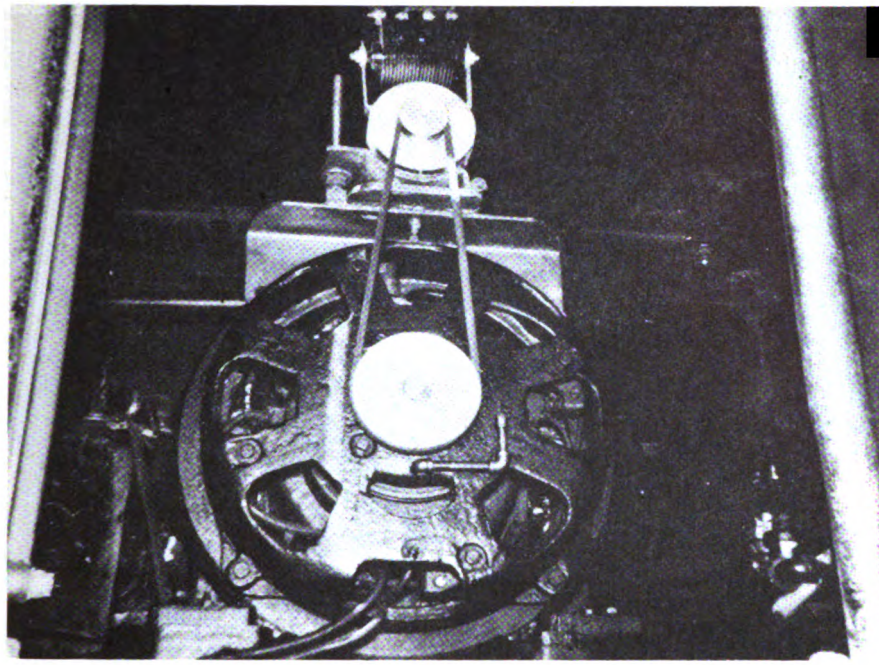

Figure 3. - Battery-charging unit mounted in locomotive.

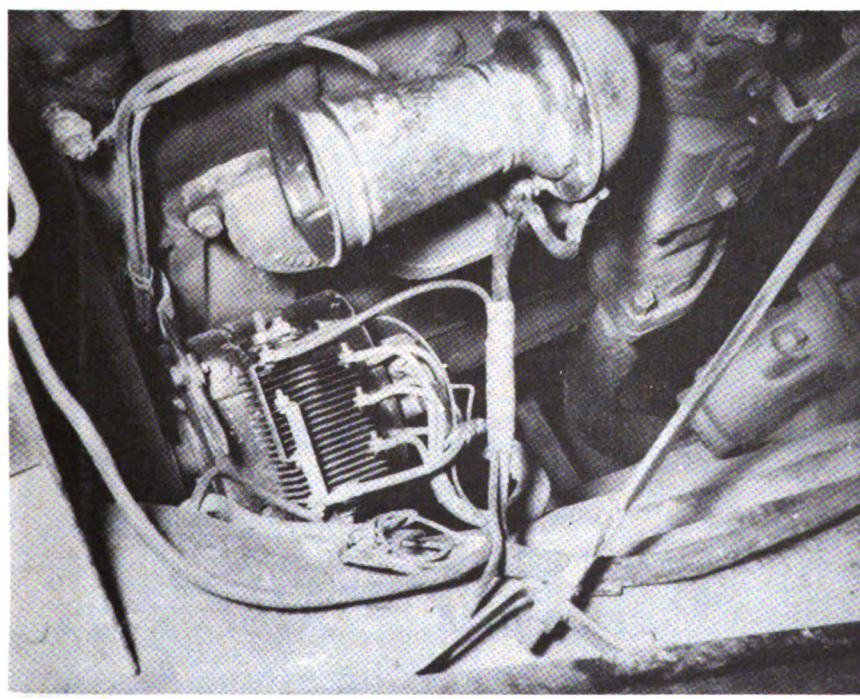

Figure 4. - Heavy-duty generator installed in truck.

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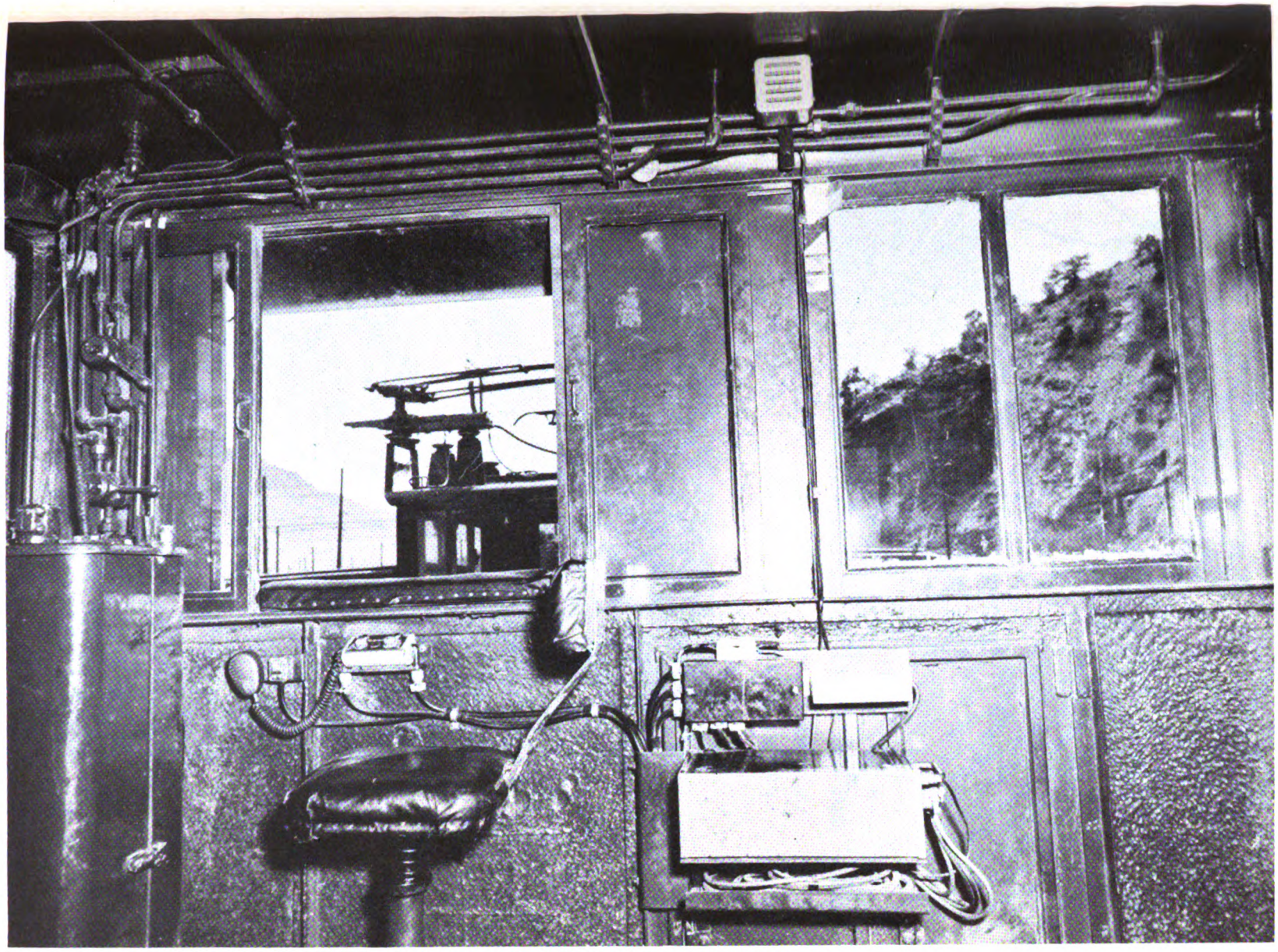

Figure 5. - Radio installation in locomotive with microphone just in front of seat.

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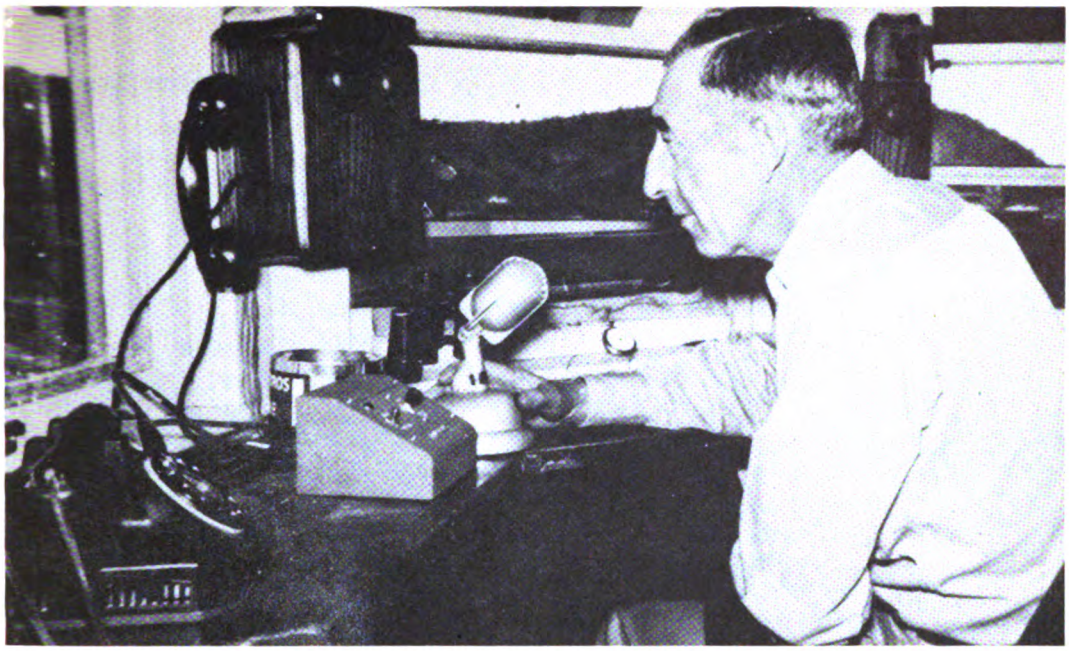

Figure 6. - Inside control tower showing special microphone and control equipment for selective signaling.

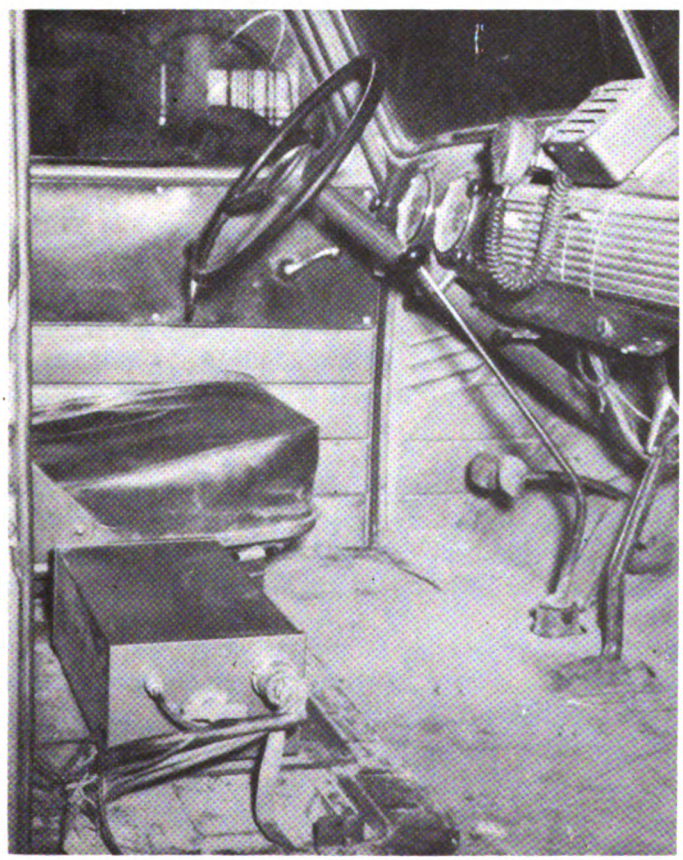

Figure 7. - Radio equipment installed in truck with microphone and speaker on dash and set to right of seat.

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The truck units are operated by the following personnel:

3 pit foremen
1 sample department
1 track department
1 general foreman
1 chief electrician
1 pit superintendent
1 powder foreman
1 electrical trouble shooter

After installation of the sets in the locomotives, a relay set was added in the control tower (figs. 5 and 6), which provides for selective communication with the locomotive engineers and eliminates possible distraction of the engineer's attention by nonpertinent calls. To use the relay set, a special microphone switch box was needed. This microphone switch box also serves the regular stationary set for open communication. To call a locomotive through the relay set, the operator presses a button switch on the microphone switch box. He is limited to 5 seconds for contacting the locomotive with the call signal. If the engineer picks up his microphone the circuit is closed, and conversation between the operator and the engineer can proceed indefinitely. If the engineer does not get the call signal or does not lift up his microphone, the operator at the control tower must repeat the procedure until contact is made.

Costs

Installation

Installation costs varied only in the type units where the sets were installed.

In the trucks the sets were installed by two men in one 8-hour shift. This included installation of the antennae on the roof of the cab, setting the transmitter-receiver and the microphone bracket, plus necessary wiring and assembly (fig. 7).

The quarter-wave antenna is used for both transmission and reception. It is comparatively short (18-13/16 inches ± 3/16 inch) and is cut to specified length at the factory. Each mobile set in use at Santa Rita occupies 137 inches of floor space and has a total weight of 32 pounds.

Installation of similar sets in the locomotives required 24 hours working time owing to the dual microphone arrangement and innovations made necessary to avoid impairment of the use of the locomotive controls. Extra time was also used in installing the generator and storage battery in the locomotive cab.

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Maintenance

Maintenance costs have been very nominal and have consisted chiefly of the replacement of tubes and vibrators which, of course, have a limited life. Some mobile units have had no repair or replacement-of-parts cost during a 12-month period. Spare tubes, vibrators, and other minor parts are kept on hand in the warehouses to expedite repair service when needed.

Equipment

The initial cost of the equipment constituted the major expense item. Company officials state that the initial cost has been repaid many times by the improved communication, which has resulted in increased production, as well as a decrease in many other expenses.

Equipment installed in the control tower cost $700.00 (1948 price). This covered the radio equipment only and did not include signaling devices, telephones, or other apparatus already in use. In the mobile units the cost of the complete set was $450.00.

Operation

"FM" radio is remarkably free from interference and clearer than telephone conversation. Electrical installations and equipment do not produce any appreciable static. The sets are easily operated. The operator merely turns the radio on and listens. When he wants to speak he pushes the "talk" button.

Mobile sets in the automobiles are operated off the regular storage battery. In other mobile units, storage batteries have been installed to provide current for the sets.

Receivers in the mobile units contain 16 tubes, and the transmitters contain 9 tubes. Both the transmitter and the receiver are crystal-controlled, so that there is never over 0.005-percent variation in frequency during the four seasons of the year.

USES OF TWO-WAY RADIO COMMUNICATION IN OPEN-PIT MINING

Under the old whistle-telephone method of communication one activity in the production of ore - moving of shovels - was carried on as follows:

The bench foreman contacted the assay department to determine the location of waste material in the pit and the ore stations near each shovel. At the same time, the dispatcher in the control tower sent word to the incoming trains by calling one of the switch tenders on the telephone. The switch tender in turn flagged the trains and gave the engineers their instructions. Often a locomotive was forced to wait on a side track until the shovel had moved to the new location; or another locomotive would have to be rerouted from an upper to a lower level to accomodate the shovel. This procedure frequently resulted in considerable delay of production, most of which was unavoidable due to the system used in communicating among the personnel involved.

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Now, with the whistle-telephone-radio communication system functioning smoothly, an operation that previously might have taken an hour to complete can be finished in a matter of minutes.

As in the foregoing instance, when the bench foreman procures the necessary information from the assay department (by radio) he contacts (by radio) all persons concerned - the dispatcher, the locomotive engineers, the shovel operators, and other foremen. The changes are made immediately and simultaneously without delay or confusion.

Foremen can also know at a moment's notice the exact nature of the material at each shovel station, as trips out of the pit to obtain this information from the assay department are now unnecessary.

Although company officials have stated that the installation of radio communication has resulted in increased production, better morale, and more efficient operation, it would be impossible to list all the benefits and advantages allied with or incident to these general results. It might be well to mention here a few of the operational advantages that have contributed to the general over-all improvement.

1. Routing of trains and locomotives. This can be done by radio from the control tower instead of by telephone to the switch points.

2. Locating shovels. The advantage of two-way radio in this operation has already been pointed out in a preceding paragraph.

3. Receiving assay reports. Time consuming trips out of the pit to secure this information are no longer necessary.

4. Reporting accidents and injuries. Quicker first-aid and medical attention is assured an injured employee after an accident.

5. In case of breakdown. Repairmen and repair parts are sped to the scene without delay.

6. In blasting. More-detailed instructions made possible by two-way radio communication have reduced the uncertainties and hazards in this operation.

7. Job instructions. Foremen can talk with each other at any time and from any point in the area so as to coordinate the work schedules better.

8. Reduction of time and travel expense in relaying or delivering messages.

Incidents of Service

An accident resulting in the injury of an employee occurred on the waste dump. The locomotive engineer immediately radioed the control tower, stating the details. The control-tower operator relayed the information by telephone to the company hospital. Without delay, the ambulance and doctor arrived at the scene of the accident, where medical aid was promptly given.

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In another instance, the writers happened to be in the control tower when a request to blast was received. The control-tower operator immediately contacted the blasting foreman by radio, received proper clearance, and the blasting signal was given. All this was accomplished within 3 minutes. Under the former signal system, it would have taken 25 to 30 minutes to complete the procedure.

A case involving a shovel breakdown points up the advantage of two-way radio communication. The pit superintendent heard a foreman at one of the shovels say the shovel was down and needed a part for the dipper. The superintendent "cut in" on the call and said he was on his way to the shops and would pick up the needed part and get it down to the shovel immediately. Needless to say, considerable time was saved, and the shovel was soon back in operation.

PLANS FOR EXPANSION

The success of the two-way radio-communication system to date has justified expansion plans devised for the whole operation at Santa Rita.

Construction permits have been received for installing two base stations and several mobile units at the company power plant 10 miles from the pit area. These will be used in case of power-line trouble and for communication between the mine and the power plant.

LICENSES

An operator licensed by the Federal Communications Commission is in charge of and responsible for the approved operation of the industrial station at the mine. In addition, each operator of the base station is licensed under the Federal Communications Act. The station's license is properly displayed in the control tower, as are the licenses of the several operators of the stationary and mobile units.

There have been no interferences, and consequently no complaints, from operators or users of other radio stations and receivers items operate on other wave lengths and frequencies in the area.

LICENSING PROCEDURE

Companies contemplating the installation of short-wave radio stations for industrial purposes are obliged by law to meet the requirements of the Federal Communications Act as outlined in Part 11, Rules Governing Industrial Radio Service. Copies of these rules may be obtained by writing the Superintendent of Documents, Washington 25, D. C., enclosing 10 cents for each copy requested.

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